USDA Forest Service Research Paper PNW - 242
1978

Survival and Growth of Planted Conifers on the Dead Indian Plateau East of Ashland, Oregon

Denis M. Williamson
Don Minore

Pacific Northwest Forest and Range Experiment Station
Forest Service U.S. Department of Agriculture
Portland, Oregon

AUTHORS

DENIS M. WILLIAMSON is a forester with the Bureau of Land Management. DON MINORE is Principal Plant Ecologist with the Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oregon.

SURVIVAL AND GROWTH OF PLANTED CONIFERS ON THE DEAD INDIAN PLATEAU EAST OF ASHLAND, OREGON

Reference Abstract

Williamson, Denis M., and Don Minore.
1978. Survival and growth of planted conifers on the Dead Indian Plateau east of Ashland, Oregon. USDA For. Serv. Res. Pap. PNW-242, 15 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Survival and growth of Douglas-fir, white fir, and ponderosa pine seedlings were studied in experimental plantations. Both bare-root and containerized seedlings were tested in the open and under partial-cut canopy. Some were caged, some watered, and some fenced. Survival of all species was much better under the partial-cut canopy than in the open, where ponderosa pine survived better than Douglas-fir or white fir. Containerized Douglas-fir and white fir seedlings grew best under the canopy. Underplanting is recommended on the Dead Indian Plateau.

KEYWORDS: Seedling survival, seedling growth, bare-root nursery stock, container nursery stock, Douglas-fir, white fir, ponderosa pine, Oregon (Dead Indian Plateau).

RESEARCH SUMMARY

Research Paper PNW-242

1978

Bare-root and containerized ponderosa pine, Douglas-fir, and white fir seedlings were planted at four severe sites on the Dead Indian Plateau. A split-split plot experimental design was used to test the influences of overstory canopy, gopher caging, cattle fencing, and irrigation on the survival and growth of these planted seedlings for two growing seasons.

The presence or absence of an overstory canopy apparently was the single most important factor in determining plantation success or failure. Survival was excellent (88.8 percent) under the partial-cut canopy, poor (36.4 percent) in the open. Ponderosa pine survival (58.6 percent) was better than either Douglas-fir (21.1-percent) or white fir (29.4-percent) survival in the open, but species survival did not differ significantly under the canopy. As caging improved survival in the open but not under the canopy, significant gopher damage apparently occurred only in the open clearcut areas.

Frost damage also was much more severe in the open clearcut areas than it was under partial-cut

canopies. Thermograph records indicated many more freezing summer nights in the open clearcuts, with minimum temperatures averaging 5°C (9°F) colder there than in adjacent partial-cut stands.

Cattle fencing noticeably increased the density and height of competing vegetation in the open cleacut areas but did not significantly affect seedling survival. Unusually wet summers probably eliminated the effect of this vegetative competition. Unusually wet weather also probably was associated with the lack of any significant irrigation effect.

Survival of the bare-root stock (65.3 percent) was better than survival of containerized seedlings (59.9 percent). Under the canopy, however, where most of the survival occurred, containerized seedlings grew significantly faster than bare-root seedlings. This superior containerized growth was particularly noticeable in the Douglas-fir and white fir stock. It was much less evident in ponderosa pine.

Our data indicate that plantations in open, clearcut areas are less likely to succeed than those established under overstory canopies on the Dead Indian Plateau; but ponderosa pine is more successful than Douglas-fir or white fir in these open areas. As planted seedlings survive and grow satisfactorily under a protective canopy cover, more should be planted there. Containerized Douglas-fir and white fir are suitable for this underplanting.

Contents

Introduction

The Dead Indian Plateau east of Ashland, Oregon is a notoriously poor area for forest regeneration. Naturally established seedlings are scarce or absent in many locations. Plantation failures are common. Many old clearcut areas remain poorly stocked after repeated planting attempts, and many old partially cut stands fail to regenerate naturally.

Reconnaissance of the plateau and discussion of the problem with knowledgeable local residents suggested several possible reasons for poor forest regeneration. Damage from pocket gophers, cattle, drought, and frost seemed to be the most probable causes of poor seedling survival.

The Dead Indian Plateau supports a dense population of pocket gophers (Hermann and Thomas 1963, Hooven 1971). Large populations of these rodents can be a significant cause of seedling mortality. Losses result from root clipping, stem girdling, top clipping, and seedling burial or root exposure associated with burrowing activities (Hermann and Thomas 1963, Trevis 1956). Hanson and Reid (1973) found that young trees were often debarked from 3 to 5 feet (0.9 to 1.5 m) above the ground when they were covered with snow.

Certain areas are heavily grazed by cattle, which roam freely on the plateau. No grazing data are available, but extensive trampling has been observed in some clearcut areas frequented by cattle. Partially cut stands seem less affected.

Although Minore and Carkin[1/] measured only moderate plant moisture stresses in 5-foot-(2-m-) tall conifer saplings growing on the Dead Indian Plateau in 1973, these stresses were recorded under overstory canopies...not in exposed clearcut situations. They measured serious soil moisture deficits in the top 10 cm during 1974. Summer drought may seriously affect young seedlings, particularly in exposed situations where vegetative competition is severe.

Elevations of 4,000 to 6,000 feet (1 220 - 1 830 m) and gentle topography combine to create serious frost problems on the plateau. Freezing or subfreezing night temperatures are not uncommon, even in the summer. Frost-damaged seedlings and saplings can be found on many poorly stocked sites.

All of these environmental factors (gophers, cattle, drought, and frost) probably reduce seedling survival and growth on the Dead Indian Plateau. They are difficult to isolate and measure directly but can be assessed indirectly by applying treatments designed to modify or eliminate factors, one by one. Treated seedlings or plots can then be compared with each other and with untreated controls to obtain data useful in evaluating the relative importance of each environmental factor and its interaction with other factors.

Using the treated seedlings and experimental plantations described in this paper, we sought answers to the following questions:

1. Which environmental factors most influence seedling survival and growth on the Dead Indian Plateau?

2. Can seedling survival be improved by planting under overstory canopies or by using different species and/or stock types?

3. Of the three species tested, what are the best species-stock combinations for clearcuts and for partial-cut stands?

Methods

The four plantations illustrated in figures 1-4 and described in

---

[1/] Unpublished data on file at the Forestry Sciences Laboratory, Corvallis, Oregon.

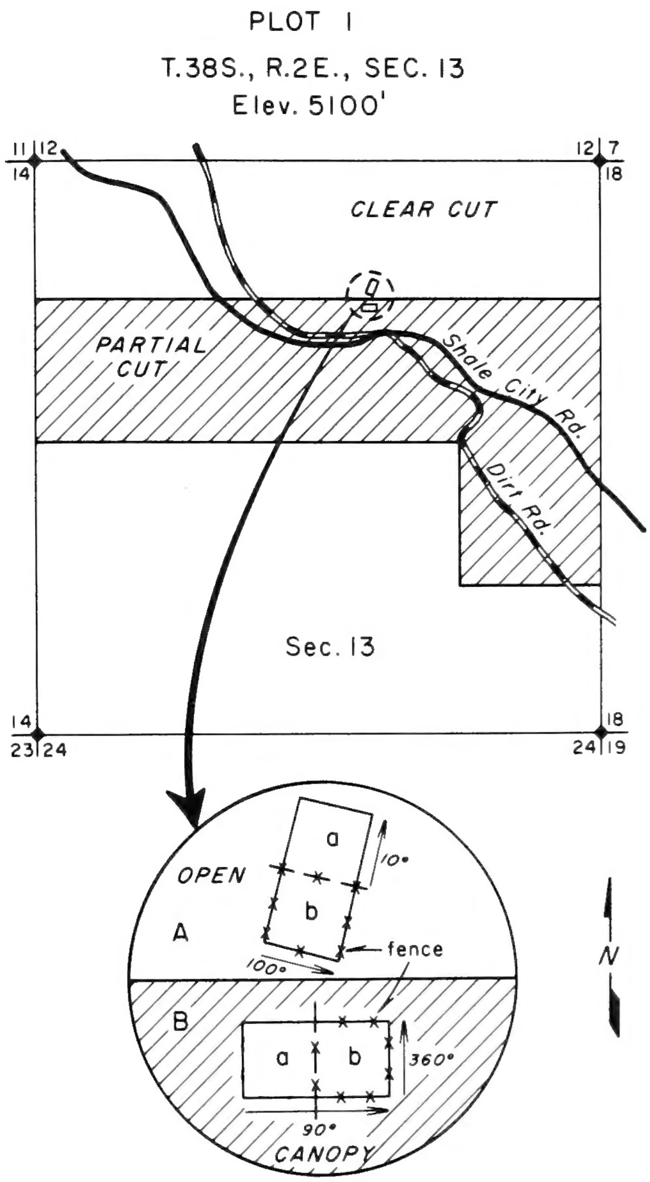

Figure 1.--Location and plot orientation of plantation 1.

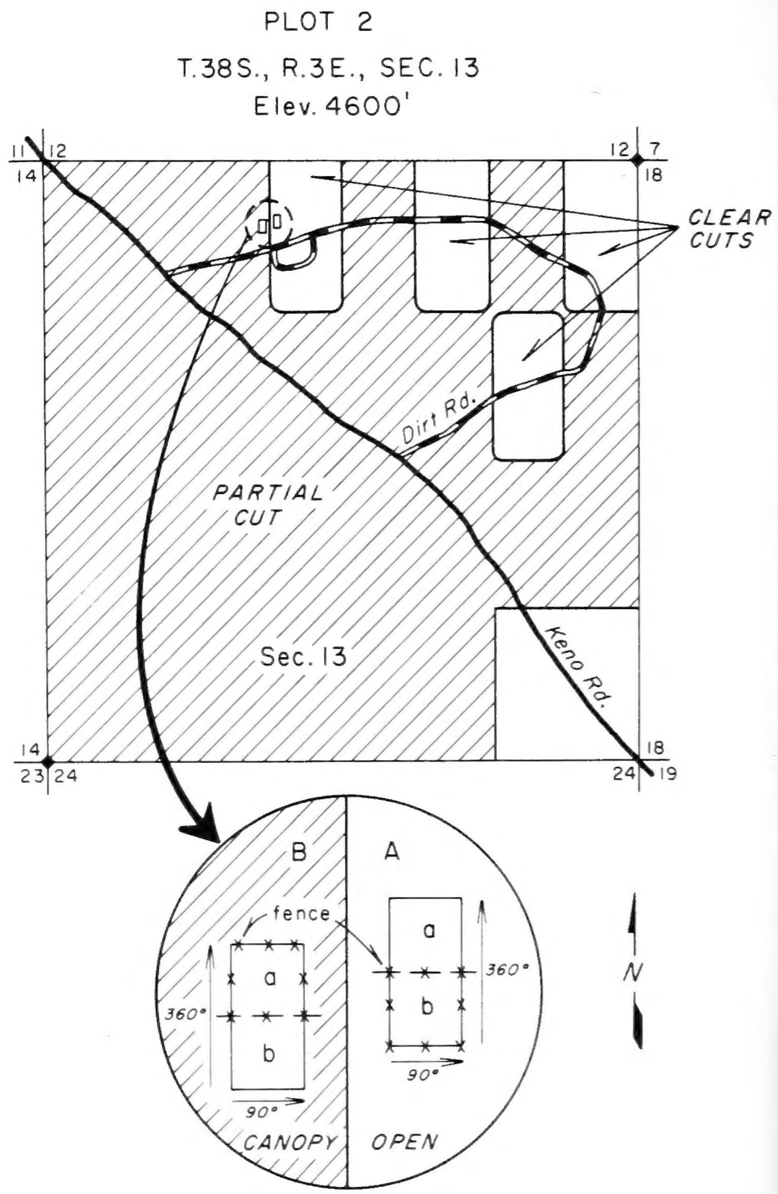

Figure 2.--Location and plot orientation of plantation 2.

table 1 were established in a split-split plot experimental design on the Dead Indian Plateau in the spring of 1975.[2/] Each plantation consisted of two 100- by 200-foot (30.5- by 61-m) plots--one located under a partial-cut canopy, the other in an adjacent, previously forested open area. Each of these plots was then further divided into two 100- by 100-foot (30.5- by 30.5-m) subplots, resulting in four subplots in each plantation. One subplot under the canopy and one in the open were randomly chosen and fenced for cattle protection at each of the four plantation sites.

The following treatments were randomized on each of the four subplots (open-fenced, open-unfenced, canopy-fenced, and canopy-unfenced) in each plantation: Douglas-fir,

[2/] Except for one plot owned by Carl Wimberly, all were on Bureau of Land Management lands.

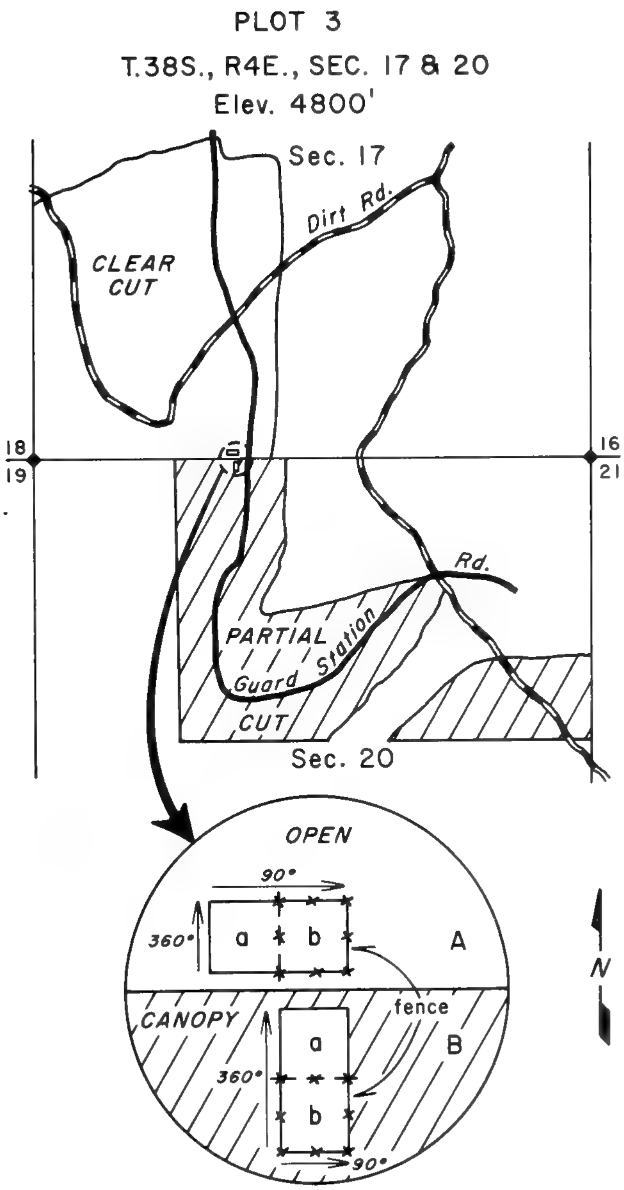

Figure 3.--Location and plot orientation of plantation 3.

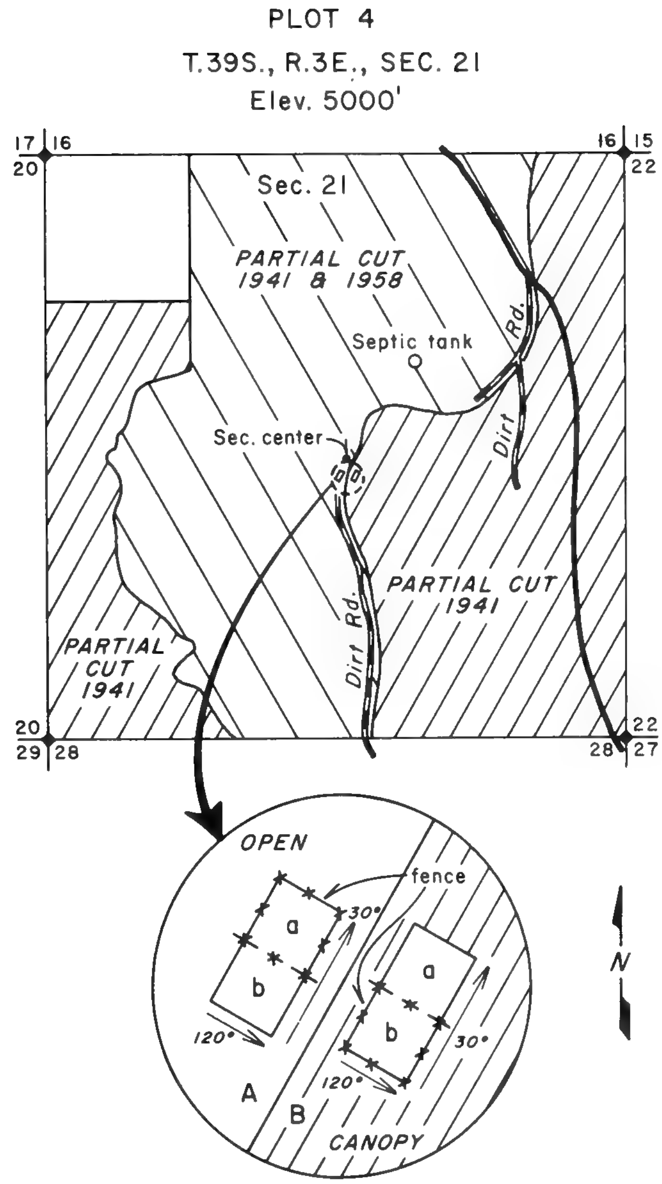

Figure 4.--Location and plot orientation of plantation 4.

Table 1--*Plantation logging dates, slopes, aspects, and partial-cut overstory characteristics*

Plantation number	Logging dates		Slope	Aspect	Partial-cut overstory		
	Open plot	Canopy plot			Basal area		Crown density
			Percent	Degrees	ft^2/acre	m^2/ha	Percent
1	Before 1966	1966	15	340	111	25.5	57
2	1960	1969, 1971	5	320	156	35.8	69
3	1948 - 1968	1961, 1968	5	270	164	37.6	60
4	1941, 1958	1941	0	level	155	35.6	61

white fir, or ponderosa pine; bare-root or containerized; caged or uncaged; watered or unwatered.

Each species-stock-treatment combination was replicated six times in each subplot. Thus, 144 seedlings were planted on each of the 4 subplots in each of the 4 plantations.

Soils on all four plantations were formed from basic volcanic colluvium. They are moderately deep and well drained. The soil of plantation No. 1 is slightly cobbled, with a few surface stones. Cobbles are rare in plantation No. 2 soil, and there are no surface stones. The soils of plantations No. 3 and No. 4 are very cobbly, with many surface stones. Forest regeneration was very poor on all four of the plantation areas, both in the open and under the adjacent partially cut stands.

Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*) and ponderosa pine (*Pinus ponderosa*) seedlings were grown from seed obtained by the Bureau of Land Management from the Dead Indian Plateau. A total of 2,304 seedlings (768 of each species) were used for the study. Half were bare-root, 2-0 stock and half were 1-year-old container-grown seedlings.

The bare-root Douglas-fir and white fir seedlings were grown at Wind River Nursery near Carson, Washington, and the bare-root ponderosa pine seedlings were grown at the U.S. Forest Service Bend Nursery in Oregon. Wind River seedlings were shovel-lifted on March 7, 1975, while still dormant. After lifting they were graded, bundled, and transported to Corvallis in ice-cooled chests. At Corvallis they were placed in a cold storage room maintained at 1°C. Using the same methods, the ponderosa pine seedlings were lifted at Bend on March 10 and immediately placed in cold storage with the Wind River stock.

Container stock was grown in 4-cubic inch (65.5 cc) plug-mold Styroblock containers for 1 year at Corvallis, Oregon.[3/] Standard procedures were used, including weekly watering and biweekly fertilization. The container-grown seedlings were put into plastic bags in groups of 25 and placed in cold storage with the bare-root stock on March 12, 1975.

Before planting, 3-foot-(.9-m-) diameter planting spots were scalped in the open areas on all four plantations. After randomization (fig. 5), flagged wires were marked and placed on each planting spot to designate the species, stock type, and treatment to be applied.

Planting began as soon as the study areas were accessible--May 19, 1975. The seedlings were kept in iced coolers until needed, then wrapped in wet burlap as they were removed for planting. They were planted at 8- by 8-foot (2.4-by 2.4-m) spacings by predetermined, randomly assigned treatment designations at each planting spot.

Half of the seedlings were caged in .5-inch (1.3-cm) mesh hardware cloth for rodent protection. The cages consisted of two sections, each 5 inches (12.7 cm) in diameter and 1 foot (.3 m) in length, with one closed end. One section was placed underground with the seedling's roots inside at time of planting (fig. 6), while the other section was placed over the seedling in late fall and attached to the bottom half (fig. 7). This upper section was designed to eliminate aboveground damage from rodents burrowing under snow.

Seven workers planted the seedlings. Using a shovel, each progressed along an assigned row to install the species, stock types, and caging treatments as they occurred. Planting was completed on June 5, 1975. Initial seedling heights were measured, cattle fences were constructed (fig. 8), and weather stations were set up soon after planting was completed.

[3/] Dian Wessbecher, Peyton Owston, and William Stein grew these seedlings. Their help is gratefully acknowledged.

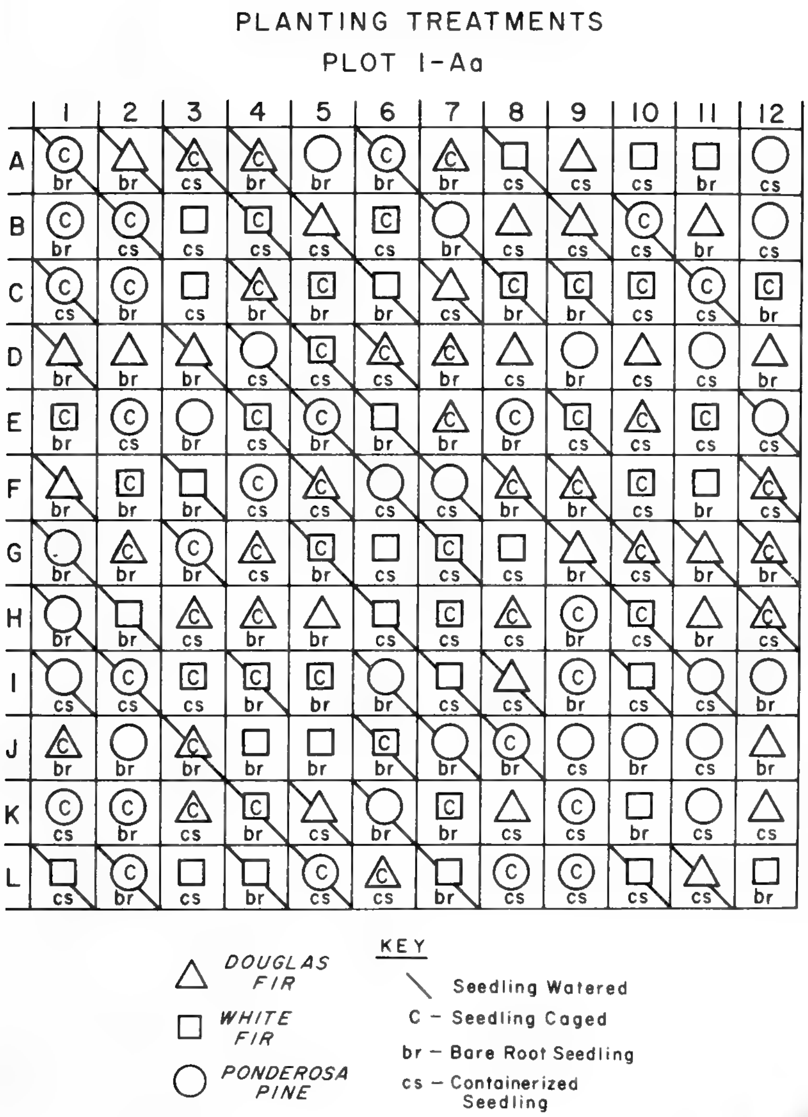

Figure 5.--Randomization of species, stock types, caging, and watering in the unfenced subplot in the open at plantation 1. (Randomization of other subplots and plantations is available on request from the Forestry Sciences Laboratory, Corvallis, Oregon.)

Figure 6.--Container-grown Douglas-fir seedling being planted in a rodent protection cage.

Temperature recorders with shielded probes were used to monitor air temperatures 8 inches (20 cm) above the soil surface. Each of the four plantations had two recorders--one under the canopy and one in the open. Summer precipitation was measured with plastic-wedge rain gages.

Half of the seedlings were irrigated during the summers of 1975 and 1976 by hand-applying 1 gallon (3.8 liters) of water per month to each. The first watering began on June 12, 1975. It was repeated monthly during the two growing seasons, with the last application on September 18, 1976.

Figure 7.--Complete rodent protection cage just before removal of the upper portion on May 14, 1976. (Only the subsurface portion remained in place during growing seasons.)

Figure 8.--Cattle fence on the open portion of plantation 2 in August, 1976. Note the difference in vegetation outside (right) and inside (left) of the fence.

The upper halves of the rodent cages were wired to the lower portions late in September, 1975. They were removed on May 14, 1976. Weather instruments were stored late in September and replaced on June 14, 1976.

Seedling survival was recorded twice--1 year after planting and again after the second growing season. Growth was recorded by remeasuring seedling heights after the second growing season. Both survival and growth then were subjected to split-split plot analyses of variance.

Seedlings were examined each month during the growing seasons (May through September) of 1975 and 1976. During these examinations, the nature, degree, and amount of damage were recorded. Lawrence and Hartwell (1961) were referred to in determining wildlife damage.

Results and Discussion

GENERAL OBSERVATIONS

Although seedlings were also damaged by drying, uprooting, breakage, burial, barking, trampling, and clipping, freezing appeared to be one of the most important factors affecting seedling mortality. It was most serious in the open, clearcut areas (table 2). Frost damage was first observed in August, 1975 on Douglas-fir and white fir seedlings--first on container-grown, then on bare-root stock. Areas receiving the most frost--the open plots--sustained the highest mortality. For example, the open plot in plantation No. 3 had 21 freezing nights and a minimum temperature of -8°C (18°F) during August, 1975; and survival was only 30 percent there. The canopied plot in this plantation had only three freezing nights and a minimum of -3°C (27°F)

Table 2--*Number of freezing ($\leq 0^{o}C$) nights on four plantations by year, month, and overstory canopy condition*[1/]

Year and month	Plantation 1		Plantation 2		Plantation 3		Plantation 4	
	Open	Canopy	Open	Canopy	Open	Canopy	Open	Canopy
	Number of freezing nights							
1975								
July	0	0	2	0	5	1	2	0
August	1	0	19	7	21	3	11	1
September	1	0	25	2/	25	1	8	0
1976								
June 15-June 30	10	2	12	9	2/	13	5	6
July	0	2	2	2/	2/	13	1	1
August	1	0	3	2/	4	1	1	4
September	2	0	7	8	14	1	5	2

[1/]Temperatures were recorded 8 inches (20 cm) above the soil surface.

[2/]Data missing because of thermograph malfunctions.

during the same period, with 88-percent survival. Similar temperature differences were recorded in the other plantations...the average minimum temperature for all open plots was 5°C (9°F) colder than the average minimum for canopied plots. As Cochran (1969) also observed, clearcut open areas apparently accumulate cold air. On the Dead Indian Plateau, this seems especially true where the topography is level or concave. The open plot on plantation No. 1 (15-percent slope) had only 1 freezing night

Figure 9.--Top of container plug exposed by surface erosion. This ponderosa pine seedling is in poor condition, but it survived. Most containerized seedlings died when plug tops were exposed.

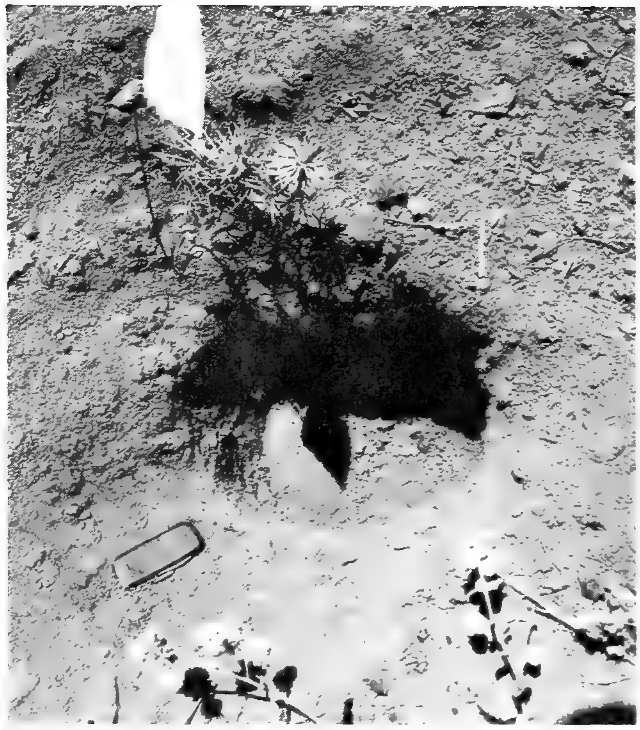

Figure 10.--Cattle-damaged seedling with hoof print.

during August, 1975, while plantations No. 2 and No. 3 (5-percent slopes) had 19 and 21 freezing nights, respectively.

The unusually wet summers of 1975 and 1976 obscured any beneficial effects of watering, and no drought damage was observed. Four inches (10 cm) of rain fell from June through September in 1975; 6 inches (15 cm) fell for the same period in 1976. Most of this precipitation occurred as intense summer downpours that often washed the surface soil away from containerized seedlings in the open plots, exposing plug tops (fig. 9). This seems to have initiated a wicking effect that dried out the plugs and killed affected seedlings.

A few containerized seedlings were damaged by deer trampling, and some deer browsing occurred when foliage was succulent in the spring. Cattle damage occasionally occurred from trampling on moist soil (fig. 10). Most gopher damage resulted from clipping seedlings at ground level, but the gophers also fed on roots; and a few seedlings were pulled underground, buried under gopher mounds, or uprooted by burrowing. Gopher damage usually resulted in seedling mortality.

SURVIVAL

Survival data were analyzed for two periods--at the end of 1 year from outplanting (mid-May, 1976) and at the end of the second growing season (late September, 1976). These data are herafter referred to as spring and fall survival.

As survival differences between plantations were not statistically significant, fall survival on all four plantations were combined in compiling table 3. This table summarizes treatment effects, but the large amount of data included makes interpretation difficult. Moreover, spring vs. fall comparisons are impossible. Accordingly, individual treatment, species, and stock-type comparisons were made by examining pertinent portions of the overall analysis.

Survival was better ($P<.05$)[4/] under the canopied areas than in the open for both spring and fall seedling counts (table 4). Species survival also differed ($P<.01$) in both counts (table 5). Most of these differences can be attributed to better ponderosa pine survival in the clearcuts. Bare-root stock also survived better ($P<.01$) than container-grown stock in both spring and fall (table 6).

Caged seedlings survived better than uncaged seedlings in both spring and fall (table 7. Spring $P<.05$, Fall $P<.01$). The cages effectively protected seedlings (fig. 11). As the caged vs. uncaged difference was much greater in the fall than it was in the spring, rodent damage apparently was most severe during the growing season. An atypical winter in 1975-1976 may have caused this by reducing the normal winter damage associated with gophers tunnelling under snow. Local plateau residents observed that snow depths never exceeded 1 foot (.3 m), and many clearcut areas were bare all winter. Atypical, wet summers in 1975 and 1976 probably negated the watering treatment; and there were no significant survival differences associated with watering. Neither were there any significant survival differences associated with fencing.

Survival did not differ significantly among species growing under the canopy, but it differed greatly ($P<.01$) when species were compared in the open (table 8). Ponderosa pine survival was almost twice that of the other species.

There were significant canopy-caging interactions in both spring ($P<.05$) and fall ($P<.01$) measurements (table 9). Caging improved survival only in the open areas. Gophers were either more concentrated in the open or they preferred other species under the canopy for food.

Ponderosa pine benefitted more from caging than either white fir or Douglas-fir (table 10). This could be the result of a species preference by gophers, but it also may reflect the fact that most surviving seedlings in the open were ponderosa pines.

GROWTH

Excessive mortality in the open made complete statistical analyses of growth in the clearcuts impractical, so growth data for all species and all areas were analyzed for the canopied areas only. When species and treatments were combined in this canopy analysis, average growth on the four plantations differed significantly ($P<.05$):

Plantation number	Average 2-year growth (cm)
1	6.3
2	11.2
3	6.0
4	5.9

Obviously, the significant growth difference occurred on plantation No. 2.

[4/] Probability figures in parenthese refer to levels of statistical significance.

Table 3--*Seedling survival (%) as tallied in late September, 1976 for all four plantations combined by species, stock types, and treatment*[1/]

Species and stock type	Treatment																Average all treatments
	Canopy								Open								
	Fenced				Unfenced				Fenced				Unfenced				
	Watered		Unwatered		Watered		Unwatered		Watered		Unwatered		Watered		Unwatered		
	Caged	Uncaged	Caged	Uncaged	Caged	Uncaged	Caged	Uncaged	Caged	Uncaged	Caged	Uncaged	Caged	Uncaged	Caged	Uncaged	
	Survival in percent																
Douglas-fir																	
Bare-root	91.6	95.8	100.0	87.5	83.3	91.6	91.7	95.8	29.2	16.7	16.7	25.0	37.5	16.7	29.2	25.0	58.33
Containerized	75.0	79.2	87.5	83.3	87.5	83.3	87.5	91.7	4.2	8.3	25.0	12.5	16.7	25.0	25.0	25.0	51.04
White fir																	
Bare-root	87.5	87.5	95.8	83.3	79.2	95.8	91.6	87.5	41.6	16.7	45.8	41.7	29.2	16.7	29.2	25.0	59.63
Containerized	87.6	91.6	95.8	91.6	87.5	83.3	100.0	79.2	33.4	37.5	41.7	25.0	25.0	20.8	29.2	12.5	58.86
Ponderosa pine																	
Bare-root	95.8	95.8	91.6	91.7	91.6	95.8	79.2	95.8	87.5	50.0	83.4	41.7	70.8	54.2	79.2	41.7	77.86
Containerized	87.5	75.0	100.0	83.3	79.2	91.6	95.8	75.0	70.8	50.0	79.2	50.0	58.3	29.2	54.2	37.5	69.79
Average, all species and stock types	87.50	87.48	95.12	86.78	84.72	90.23	90.97	87.50	44.45	29.87	48.63	32.65	39.58	27.10	41.00	27.78	62.58

[1/] Each percentage shown here is based upon 24 seedlings--6 in each treatment, on each of 4 plantations.

Table 4--*Survival in canopied and open areas*

Measurement season	Survival percent		Statistical significance of differences
	Canopy	Open	
Spring, 1976	92.5	50.4	P<.05
Fall, 1976	88.8	36.4	P<.05

Table 5--*Survival by species*

Measurement season	Survival percent			Statistical significance of differences
	Douglas-fir	White fir	Ponderosa pine	
Spring, 1976	65.5	66.9	82.0	P<.01
Fall, 1976	54.7	59.2	73.8	P<.01

Table 6--*Survival by stock-type*

Measurement season	Survival percent		Statistical significance of differences
	Containerized	Bare-root	
Spring, 1976	68.4	74.6	P<.01
Fall, 1976	59.9	65.3	P<.01

Table 7--*Survival by caging treatment*

Measurement season	Survival percent		Statistical significance of differences
	Not caged	Caged	
Spring, 1976	69.4	73.6	P<.05
Fall, 1976	58.7	66.5	P<.01

Figure 11.--Evidence of caging success. A gopher approached this seedling from the left rear (surface trench made under the snow), then burrowed completely around the cage perimeter (mounds surrounding bottom of cage). The seedling was not injured.

Caged seedlings under the canopy grew better ($P<.05$) than uncaged seedlings:

Caged 7.7-cm average growth
Uncaged 7.1-cm average growth

Caging, however, may have influenced growth through factors other than gopher protection...it probably protected seedlings from snow damage, debris from overstory trees, and deer.

When all species were combined, containerized stock grew better ($P<.01$) under the canopy than bareroot stock (table 11). There also

Table 8--*Survival in canopied and open areas, by species*[1/]

Measurement season	Survival percent					
	Canopy			Open		
	Douglas-fir	White fir	Ponderosa pine	Douglas-fir	White fir	Ponderosa pine
Spring, 1976	93.0	92.4	92.2	38.0	41.4	71.9
Fall, 1976	88.3	89.1	89.1	21.1	29.4	58.6

[1/] Species differences were not significant under the canopy. They were highly significant ($P< .01$) in the open.

Table 9--*Survival in canopied and open areas, by caging treatment*

Measurement season	Survival percent			
	Canopy		Open	
	Not caged	Caged	Not caged	Caged
Spring, 1976	92.7	92.4	46.0	54.9
Fall, 1976	88.0	89.6	29.3	43.4

1/ Caging differences were not significant under the canopy. They were significant in the open (Spring P<.05, Fall P<.01). The canopy-caging interactions also were statistically significant.

Table 10--*Fall survival by species and caging treatment* 1/

Caging treatment	Survival Percent		
	Douglas-fir	White fir	Ponderosa pine
Not caged	53.9	56.0	66.1
Caged	55.5	62.5	81.5

1/ The species-caging interaction was significant (P<.05).

Table 11--*Two-year growth under the canopy, by species and stock type*

Stock types	Average growth (cm)			
	Douglas-fir 1/	White fir 1/	Ponderosa pine 2/	All species 3/
Containerized	8.5	8.5	7.6	8.2
Bare-root	6.7	6.0	7.1	6.6
All stock types 2/	7.6	7.2	7.3	7.4

1/ The difference was significant (P<.05).

2/ The differences were not statistically significant.

3/ The difference was highly significant (P<.01).

was a species-stock type interaction ($P<.05$). Containerized Douglas-fir and white fir seedlings grew significantly better than bare-root stock. Ponderosa pine seedlings did not. When stock types were combined, the growth differences among species were not statistically significant.

Fencing and watering had no significant effects upon seedling growth. If the summers of 1975 and 1976 had been more typical (drier), growth differences probably would have been greater.

Conclusions

Several variables affected seedling survival and growth in these experimental plantations, but frost and pocket gophers seemed to be the most important. Both were strongly associated with the open areas created by overstory canopy removal. Therefore, the presence or absence of an overstory canopy apparently is the single most important factor in determining plantation success or failure on the Dead Indian Plateau. Plantations in open, clearcut areas are less likely to succeed then those established under overstory canopies.

In clearcut areas, ponderosa pine seedlings survive better than white fir or Douglas-fir seedlings; however, other frost hardy species should be investigated. Cochran and Berntsen (1973) reported lodgepole pine seedlings to be even more cold tolerant than those of ponderosa pine, and Black and Hooven (1977) recorded better survival of lodgepole pine, ponderosa pine, and incense-cedar than of Douglas-fir and white fir on Dead Indian clearcuts. Selected local Douglas-fir stock with inherent frost hardiness should also be tried. In localized areas, such as clearcuts on south slopes, shading and/or frost protection of individual seedlings may be beneficial. Although not tested on the experimental plantations, this has been observed elsewhere on the plateau where live and dead shade were related to seedling survival and growth (Minore 1971).

As planted seedlings survive and grow satisfactorily under a protective canopy cover, more should be planted there in the Dead Indian area. Optimum timing has not been determined yet, but overstory removal should be delayed until after seedlings are fully established and large enough to withstand severe frosts. As measured by spherical densiometer, optimum overstory density for natural regeneration is about 60 percent (Minore and Carkin 1977). The minimum shelterwood overstory density required for satisfactory plantation survival should be determined and incorporated into management practices.

Containerized Douglas-fir and white fir seedlings grew best under overstory canopies on the experimental plantations. This indicates that these species may be underplanted successfully as containerized stock; however, further study of understory planting and overstory removal is needed. Seedling survival and response after overstory canopy removal should be understood better before this or any other underplanting technique is extensively used.

Literature Cited

Black, Hugh C., and Edward F. Hooven.
1977. Effects of herbicide-induced habitat changes on pocket gophers in southwestern Oregon. Proc. 29th Ann. Calif. Weed Conf., Jan. 1977, p. 119-127.

Cochran, P. H.
1969. Lodgepole pine clearcut size affects minimum temperatures near the soil surface. USDA For. Serv. Res. Pap. PNW-86, 9 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Cochran, P. H., and Carl M. Berntsen.
1973. Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures. For. Sci. 19(4):272-280.

Hanson, Richard M., and Vincent H. Reid.
1973. Distribution and adaptations of pocket gophers. p. 1-19 *In* Pocket gophers and Colorado

mountain rangeland. Colorado State Univ. Exp. Stn., Fort Collins, Colorado. Bulletin No. 554. 90 p.

Hermann, Richard K., and Harold A. Thomas.
1963. Observations on the occurrence of pocket gophers in southern Oregon pine plantations. J. For. 61(7):527-529.

Hooven, Edward F.
1971. Pocket gopher damage on ponderosa pine plantations in southwestern Oregon. J. of Wildlife Manage. 35(2):346-353.

Lawrence, W. H., and Harry D. Hartwell.
1961. Guide to wildlife feeding injuries on conifers in the Pacific Northwest. Western Forestry and Conservation Assoc. Portland, Oreg. 44 p.

Minore, Don.
1971. Shading benefits Douglas-fir in southwestern Oregon cutover area. Tree Planters' Notes 22(1):22-23.

Minore, Don, and Richard E. Carkin.
1978. Vegetative indicators, soils, overstory canopy, and natural regeneration after partial cutting in the Dead Indian Plateau area of southwestern Oregon. USDA For. Serv. Res. Note PNW-316, 9 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Trevis, L., Jr.
1956. Pocket gophers and seedlings of red fir. Ecology 37:379-381.

GPO 986-674

Williamson, Denis M., and Don Minore.
1978. Survival and growth of planted conifers on the Dead Indian Plateau east of Ashland, Oregon. USDA For. Serv. Res. Pap. PNW-242, 15 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Survival and growth of Douglas-fir, white fir, and ponderosa pine seedlings were studied in experimental plantations. Both bare-root and containerized seedlings were tested in the open and under partial-cut canopy. Some were caged, some watered, and some fenced. Survival of all species was much better under the partial-cut canopy than in the open, where ponderosa pine survived better than Douglas-fir or white fir. Containerized Douglas-fir and white fir seedlings grew best under the canopy. Underplanting is recommended on the Dead Indian Plateau.

KEYWORDS: Seedling survival, seedling growth, bare-root nursery stock, container nursery stock, Douglas-fir, white fir, ponderosa pine, Oregon (Dead Indian Plateau).

Williamson, Denis M., and Don Minore.
1978. Survival and growth of planted conifers on the Dead Indian Plateau east of Ashland, Oregon. USDA For. Serv. Res. Pap. PNW-242, 15 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Survival and growth of Douglas-fir, white fir, and ponderosa pine seedlings were studied in experimental plantations. Both bare-root and containerized seedlings were tested in the open and under partial-cut canopy. Some were caged, some watered, and some fenced. Survival of all species was much better under the partial-cut canopy than in the open, where ponderosa pine survived better than Douglas-fir or white fir. Containerized Douglas-fir and white fir seedlings grew best under the canopy. Underplanting is recommended on the Dead Indian Plateau.

KEYWORDS: Seedling survival, seedling growth, bare-root nursery stock, container nursery stock, Douglas-fir, white fir, ponderosa pine, Oregon (Dead Indian Plateau).

Williamson, Denis M., and Don Minore.
1978. Survival and growth of planted conifers on the Dead Indian Plateau east of Ashland, Oregon. USDA For. Serv. Res. Pap. PNW-242, 15 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Survival and growth of Douglas-fir, white fir, and ponderosa pine seedlings were studied in experimental plantations. Both bare-root and containerized seedlings were tested in the open and under partial-cut canopy. Some were caged, some watered, and some fenced. Survival of all species was much better under the partial-cut canopy than in the open, where ponderosa pine survived better than Douglas-fir or white fir. Containerized Douglas-fir and white fir seedlings grew best under the canopy. Underplanting is recommended on the Dead Indian Plateau.

KEYWORDS: Seedling survival, seedling growth, bare-root nursery stock, container nursery stock, Douglas-fir, white fir, ponderosa pine, Oregon (Dead Indian Plateau).

Williamson, Denis, M., and Don Minore.
1978. Survival and growth of planted conifers on the Dead Indian Plateau east of Ashland, Oregon. USDA For. Serv. Res. Pap. PNW-242, 15 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Survival and growth of Douglas-fir, white fir, and ponderosa pine seedlings were studied in experimental plantations. Both bare-root and containerized seedlings were tested in the open and under partial-cut canopy. Some were caged, some watered, and some fenced. Survival of all species was much better under the partial-cut canopy than in the open, where ponderosa pine survived better than Douglas-fir or white fir. Containerized Douglas-fir and white fir seedlings grew best under the canopy. Underplanting is recommended on the Dead Indian Plateau.

KEYWORDS: Seedling survival, seedling growth, bare-root nursery stock, container nursery stock, Douglas-fir, white fir, ponderosa pine, Oregon (Dead Indian Plateau).

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research are made available promptly. Project headquarters are at:

Fairbanks, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington

Mailing address: Pacific Northwest Forest and Range Experiment Station
P.O. Box 3141
Portland, Oregon 97208

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

The U.S. Department of Agriculture is an Equal Opportunity Employer. Applicants for all Department programs will be given equal consideration without regard to race, color, sex or national origin.